

OBJECT ORIENTED METRIC BASED ANALYSIS OF SPACE EFFICIENT LSB BASED STEGANOGRAPHY INCLUDING COMPRESSION FOR SECURING TRANSMISSION OF E-LEARNING DOCUMENTS

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ABSTRACT

Transmission of documents in an e-learning system should be in a very secure manner; otherwise, if the hacker can reach the documents, they can edit or destroy the documents. In our proposed model, we have used the Least Significant Bit (LSB) based Steganography technique for hiding along with the Haar wavelet transform and PackBits algorithm for the compression. Using this model, the sender can send their material after compression, which is space efficient, and LSB steganography technique will also provide security and authenticity. Through object oriented analysis of any system, all the advantages of an object oriented approach like data redundancy, reusability, data hiding, encapsulation and polymorphism etc. can be achieved. Though there are so many types of object oriented metric analysis proposed by Lorenz and Kidd, Harrison, Counsell and Nithi etc., here we will limit our discussion on Chidamber and Kemerer metric (CK metric) and Metric for Object Oriented Design metric (MOOD metric) based on the class hierarchy diagram regarding the transmission of study material from the teacher to learner in an e-learning system.

KEYWORDS: LSB Based Steganography, E-learning, Class Hierarchy Diagram & Object Oriented Metrics

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I. INTRODUCTION

E-learning is a new trend of learning where place and time do not matter a lot and is also emerging at a great speed. The three main participants of an e-learning system – administrator or developer, teacher and student or learner^[1] use the publicly accessible Internet to transmit documents between each other, which cause a great chance of hacking. To provide security and authenticity, Least Significant Bit steganography is a very popular and known technique^[2]. Sometimes it is necessary to send a large number of documents at a time like sending study material for the teacher to learner, at that time compression technique is very much required. In our proposed model, we have applied the LSB steganography technique along with the Haar wavelet transform^[3] and PackBits algorithm^[4] to compress the data while sending.

Though there are so many object oriented metrics advised by Lorenz and Kidd, Henderson, Harrison, Lee etc., here we will discuss on the basis of two most popular metric analysis Chidamber and Kemerer Metric (CK metric) and Metric for Object Oriented Design (MOOD) metric^[5]. Since the characteristics of object oriented analysis and design are inheritance, encapsulation, data abstraction, polymorphism^[6], so all the advantages of object oriented analysis and design over the traditional system like reduction of code, an improvement in portability and flexibility^[7] etc. can be achieved through this analysis.

In this paper, we will analyze the value of the object oriented metrics of our proposed model in respect of the class hierarchy diagram regarding the transmission of study material from the teacher to learner in an e-learning system. Section II covers the class hierarchy diagram of the proposed model based on the transmission of the study material from the teacher to learner and section III includes the object oriented metric based analysis of the proposed model in respect of the class diagram and finally we conclude in section IV by showing some future scope.

II. CLASS HIERARCHY DIAGRAM

The class hierarchy diagram is a tool of structural Unified Modified Language (UML) diagram which is used to represent the object orientation of any system. It consists of classes, objects, interfaces and collaboration and generally represent the object oriented view of a system^[8]. To represent our proposed model, we have used six classes: HaarTransform, HaarTransformImage, PackBits, LSBS, Teacher and Learner^[9].

Class **Haar Transform** served the purposes of the base class. This class is used to prepare the secret image for Haar wavelet transform. It converts the secret image into binary format and transforms it accordingly and finally gets the inverse transformed matrix.

Class **Haar Transform Image** is publicly derived from the base class HaarTransform. It helps the teacher to complete the transformation of the image using Haar wavelet transform.

Class **Pack Bits** are used to apply the PackBits algorithm, which is mainly reduce the number of zeros created by her wavelet transform. It helps in the compression of the secret image to be sent from teacher to learner. It is also acting as another base class.

Class **LSBS** is publicly derived from the two classes HaarTransform Image and Pack Bits, which means Least Significant Bit Steganography and its main function is to first check the size of the secret image and the cover image, if it's okay, then embedding and decoding the secret image and the cover image.

Class **Teacher** is publicly derived from the class LSBS and used to encode the secret image into the binary cover image and create a stego image. After the encoding, teacher sends the stego image to the learner.

Class **Learner** is also publicly derived from the class LSBS and is used to decode the stego image received from the teacher. It extracts the secret image which was embedded into the cover image.

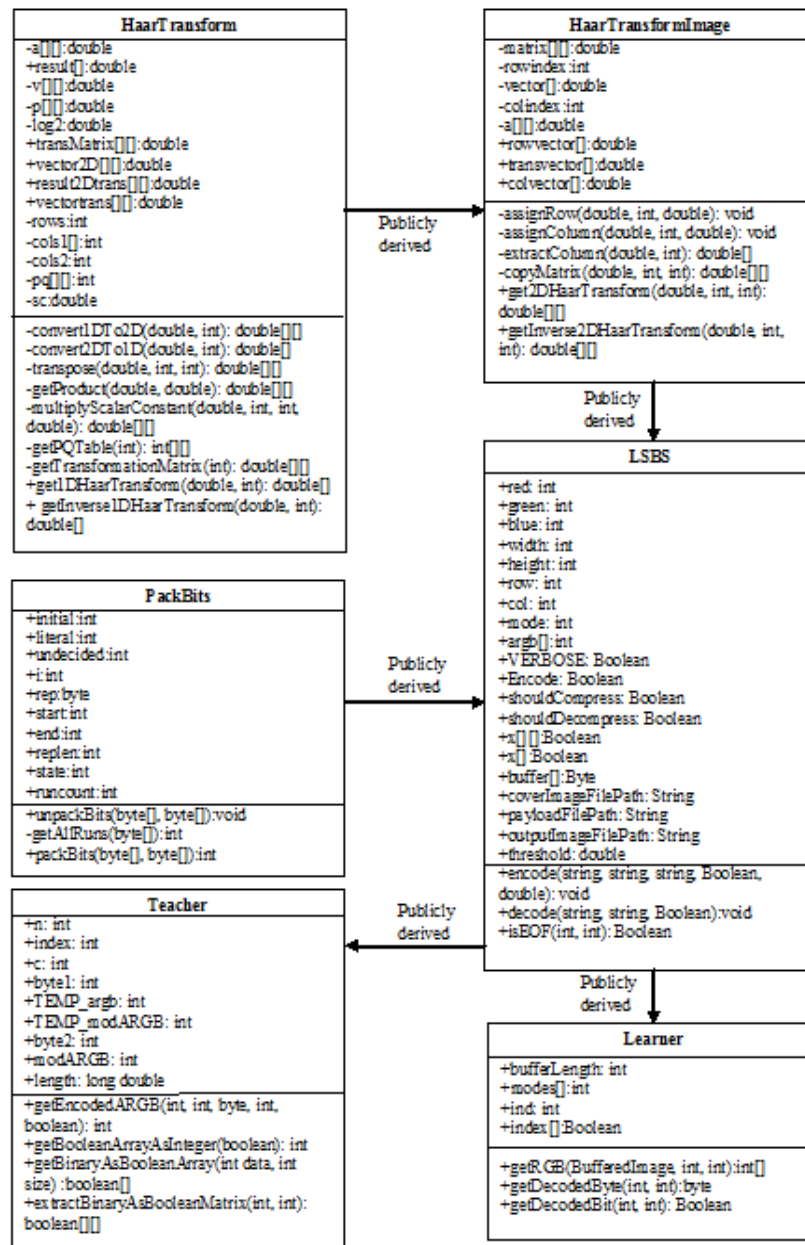


Figure 1: Class Diagram of Proposed Model Regarding the Transmission of Study Material from Teacher to Learner

III. METRIC BASED ANALYSIS

The main characteristics of the object oriented metric analysis are class, inheritance, polymorphism, coupling and cohesion. Here, we will analyze the values of our proposed model based on only CK metric and MOOD metric and discuss on the result. Some metrics of the CK metric are discussed below^[10,11].

- **NOA** (Number of Attributes): It represents the total number of attributes of the classes.
- **NOM** (Number of Methods): It represents the total number of methods present in the classes.
- **CBO** (Coupling between Objects): It counts the number of other classes to which the particular class is coupled.

- **DIT** (Depth of Inheritance Tree): It represents the depth of the class in the inheritance hierarchy. The DIT value of the base class is 0, its immediate child has a DIT value 1 and its grandchild has DIT value 2 and so on.
- **NOC** (Number of Child): It represents the number of subclasses directly inherits from that class.
- **RFC** (Response for a class): It calculates the number of methods that can be invoked in response to a message in that class.

Now, we will find the values of the above metrics in respect to our proposed model according the class diagram shown in figure 1. All the respective values of the above metrics are shown using table 1.

Table 1: Metric Values According to the Proposed Model

| Object Oriented Metrics | Classes of Proposed Model | | | | | |
|-------------------------|---------------------------|----------------------|-----------|------|---------|---------|
| | Haar Transform | Haar Transform Image | Pack Bits | LSBS | Teacher | Learner |
| NOA | 14 | 8 | 10 | 20 | 9 | 4 |
| NOM | 9 | 6 | 3 | 3 | 4 | 3 |
| CBO | 1 | 2 | 1 | 4 | 1 | 1 |
| DIT | 0 | 1 | 1 | 2 | 3 | 3 |
| NOC | 1 | 1 | 1 | 2 | 0 | 0 |
| RFC | 28 | 25 | 13 | 28 | 25 | 24 |

Now, we will graphically represent the above values and discuss on these:

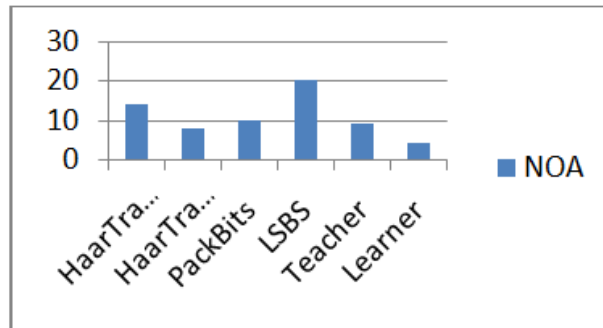


Figure 2: Values of NOA Metrics

Figure 2 shows the metric values of NOA of all the classes used in our proposed model. NOA is used for making an estimate about the required time and effort to maintain a class. Here we can see the maximum value is 20, which is okay.

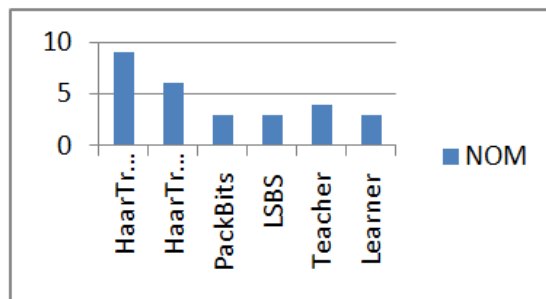


Figure 3: Values of NOM Metrics

Figure 3 shows the values of the metric NOM of all the classes used in our proposed model. NOM is also used in making estimation about the required time and effort to maintain a class. Here we can see the maximum value is 9, which indicates that the system is easy to maintain.

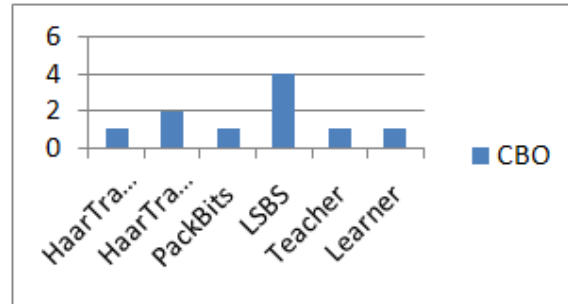


Figure 4: Values of CBO Metrics

Figure 4 shows the values of CBO metrics of all the classes. The value of 0 means the class is not a part of the system. The value ranged between 1 to 4 is good^[12], which indicates that the system is loosely coupled.

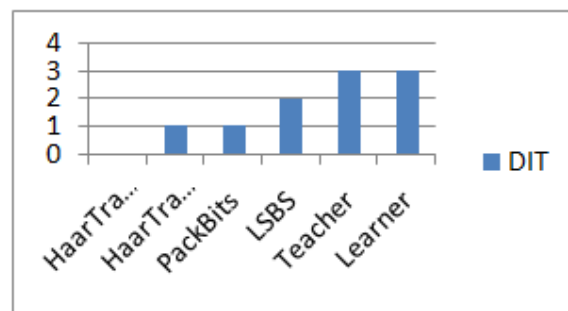


Figure 5: Values of DIT Metrics

Figure 5 shows the values of the DIT metric of the classes based on the proposed model. It helps to find the complexity of the system, which increases with the increasing value of the depth of the classes. Here, the maximum value is 3, which is acceptable.

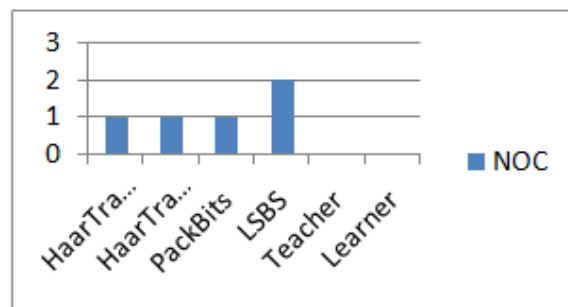


Figure 6: Values of NOC Metrics

Figure 6 shows the value of the number of child classes of all the classes. The average desirable of NOC is in between 1 and 3, which is maintained in our design^[13].

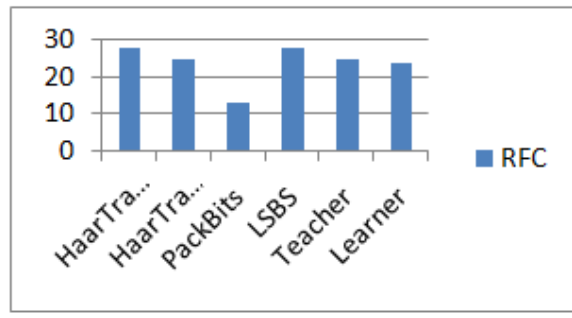


Figure 7: Values of RFC Metrics

Figure 7 shows the value of the metric RFC. It is calculated using the formula $\{M\} \cup \{R_i\}$, for all i , $\{R_i\}$ =Set of methods called by i and $\{M\}$ =Set of all methods in the class.

Now, we will discuss on the value of some metrics which are under the MOOD metrics regarding the transmission of the study material from teacher to learner in an e-learning system.

- Equation for $MHF = \sum_{i=1}^{TC} M_h(C_i) / \sum_{i=1}^{TC} M_d(C_i)$ //TC means total number of class

Where $M_d(C_i) = M_v(C_i) + M_h(C_i)$ where $M_d(C_i)$ = methods defined in class C, $M_v(C_i)$ = methods visible in class C and $M_h(C_i)$ = methods hidden in class C

Table 2: Values of MHF

| | Classes of Proposed System | | | | | | Summation (Σ) |
|------------|--|----------------------|-----------|------|---------|---------|------------------------|
| | Haar Transform | Haar Transform Image | Pack Bits | LSBS | Teacher | Learner | |
| $M_h(C_i)$ | 7 | 4 | 1 | 0 | 0 | 0 | 12 |
| $M_v(C_i)$ | 2 | 2 | 2 | 3 | 4 | 3 | 16 |
| $M_d(C_i)$ | 9 | 6 | 3 | 3 | 4 | 3 | 28 |
| MHF | 12/28=0.4286(correct up to 4 decimal places) | | | | | | |

The value of MHF of our proposed model is calculated by using Table 2, which is 0.4286. Low value of MHF means insufficiently abstracted implementation and high MHF indicates the less functionality. So, this values is okay^[14].

- Equation for $AHF = \sum_{i=1}^{TC} A_h(C_i) / \sum_{i=1}^{TC} A_d(C_i)$

$A_d(C_i) = A_v(C_i) + A_h(C_i)$, where $A_d(C_i)$ = total attributes defined in class C, $A_v(C_i)$ = Attributes visible in class C and $A_h(C_i)$ = attributes hidden in class C

Table 3: Values of AHF

| | Classes of Proposed System | | | | | | Summation(Σ) |
|------------|--|----------------------|-----------|------|---------|---------|-----------------------|
| | Haar Transform | Haar Transform Image | Pack Bits | LSBS | Teacher | Learner | |
| $A_h(C_i)$ | 9 | 5 | 0 | 0 | 0 | 0 | 14 |
| $A_v(C_i)$ | 5 | 3 | 10 | 20 | 9 | 4 | 51 |
| $A_d(C_i)$ | 14 | 8 | 10 | 20 | 9 | 4 | 65 |
| AHF | 14/65=0.2154(correct up to 4 decimal places) | | | | | | |

The AHF value of our proposed model shown in Table 3, is 0.2154, which lies in between 0 and 1, which is acceptable.

- Equation for $MIF = \sum_{i=1}^{TC} M_i(C_i) / \sum_{i=1}^{TC} M_a(C_i)$

Where $M_a(C_i) = M_d(C_i) + M_i(C_i)$, $M_a(C_i)$ =number of methods available, $M_d(C_i)$ = number of methods defined and $M_i(C_i)$ = number of methods inherited

Table 4: Values of MIF

| | Classes of proposed system | | | | | | |
|------------|--|----------------------|-----------|------|---------|---------|-----------------------|
| | Haar Transform | Haar Transform Image | Pack Bits | LSBS | Teacher | Learner | Summation(Σ) |
| $M_d(C_i)$ | 9 | 6 | 3 | 3 | 4 | 3 | 28 |
| $M_i(C_i)$ | 0 | 9 | 0 | 18 | 21 | 21 | 69 |
| $M_a(C_i)$ | 9 | 15 | 3 | 21 | 25 | 24 | 97 |
| MIF | 69/97=0.7113(correct up to 4 decimal places) | | | | | | |

The value of MIF should not be too high or too low. The acceptable range is 20% to 80%, which is followed in our design, shown using Table 4.

- Equation for $AIF = \sum_{i=1}^{TC} A_i(C_i) / \sum_{i=1}^{TC} A_a(C_i)$

Where $A_a(C_i) = A_d(C_i) + A_i(C_i)$, $A_a(C_i)$ =number of methods available, $A_d(C_i)$ = number of methods defined and $A_i(C_i)$ = number of methods inherited

Table 5: Values of AIF

| | Classes of Proposed System | | | | | | |
|------------|--|----------------------|-----------|------|---------|---------|-----------------------|
| | Haar Transform | Haar Transform Image | Pack Bits | LSBS | Teacher | Learner | Summation(Σ) |
| $A_d(C_i)$ | 14 | 8 | 10 | 20 | 9 | 4 | 65 |
| $A_i(C_i)$ | 0 | 14 | 0 | 32 | 52 | 52 | 150 |
| $A_a(C_i)$ | 14 | 22 | 10 | 52 | 61 | 56 | 215 |
| AIF | 150/215=0.6977(correct up to 4 decimal places) | | | | | | |

The value of AIF is shown using Table 5, is 0.6977. This value is also like the value of MIF and if the value is 0, means lack of inheritance. The value of our proposed model is acceptable.

IV. CONCLUSIONS

This object oriented metric analysis is done to ensure the improvement of authenticity and secrecy during the transmission of study material for the teacher to learn in any e-learning system with the help of class diagrams, and some of the metrics under Ck metric and MOOD metric to achieve the facilities of object oriented design over traditional design. Different kinds of steganography techniques other than Least Significant Bit can also be applied to get better results, which is out of scope of this paper. We have applied this model in e-learning system, but in all other electronic transactions like e-commerce and e-governance can apply this model to provide security.

REFERENCES

1. Weippl, R. E., "Security in E-Learning", Springer, 2005
2. Frank Y. Shih, "Digital watermarking and Steganography: Fundamentals and techniques", CRC Press, New Delhi, 2008
3. https://en.wikipedia.org/wiki/Haar_wavelet
4. <https://en.wikipedia.org/wiki/PackBits>

5. http://ce.sharif.edu/courses/8586/1/ce924/resources/root/4.%20Kamandi_OOMetrics.pdf
6. K. K. Aggarwal, Y. Singh, A. Kaur, R. Malhotra, "Empirical study of object oriented metrics", *Journal of Object Technology, ETH Zurich, Chair of Software Engineering*, Vol. 5, No. 8, November-December 2006, pp: 149-173
7. Rajib Mall, *Fundamentals of Software Engineering* (Prentice Hall of India, New Delhi, 2006)
8. https://www.tutorialspoint.com/uml/uml_standard_diagrams.htm
9. S. Banerjee and S. Karforma, "Applying LSB Steganography for Disseminating Academic Testimonials in e-Learning and its Authentication aspects", *International Journal of Computer Trends and Technology* (accepted)
10. S. Banerjee and S. Karforma, "Object Oriented Analysis and Design of Digital Certificate based Mark-sheet Authentication in E-learning", *Journal of Ultra scientist of Physical Sciences*, vol-28(7), Sep-Dec2016, pp: 158-162
11. S. Banerjee and S. Karforma, "Object oriented metric based analysis of DES algorithm for secure transmission of mark sheet in e-learning", *International Journal of Computer Sciences and Engineering*, vol-4(1), pp:093-098
12. http://support.objecteering.com/objecteering6.1/help/us/metrics/metrics_in_detail/coupling_between_object_classes.htm
13. http://support.objecteering.com/objecteering6.1/help/us/metrics/metrics_in_detail/number_of_children.htm
14. <http://www.aivosto.com/project/help/pm-oo-mood.html>